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Research Note

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CHIPPING TAKES THE HAZARD OUT OF LOGGING SLASH

George R. Fahnestock
Division of Fire Research

The experimental burning program which was carried on at the Priest River Experimental Forest in 1952[1/] made it possible to test the effect of chipping on the inflammability of logging slash. A portable chipper mounted on a 2-wheel trailer, loaned by the manufacturer to the U. S. Forest Service Region 1 Division of Fire Control, was made available for experimental use. Green slash put through the machine and allowed to dry for over two months could scarcely be burned at all except during the hottest part of the day. Fire behavior in the chipped slash closely resembled that in natural litter and duff.

RESEARCH METHODS

Procurement and Preparation of Slash

The experimental material consisted of live branches from tops of healthy, symmetrical trees. The trees grew in the same stand as those used for natural slash,[1/] and the tops were essentially similar as to the relative amounts of wood and needles. When the slash had been lopped and piled, equal numbers of branches from each third of the crown were chipped until sufficient weight of slash was obtained to lay out the experiment.

Chippings were laid out on plots at the same concentrations as the natural slash, namely, 7.5, 20, and 32.5 tons dry weight per acre. Plots of chipped slash, however, were only 0.001 acre in size. Each plot was surrounded by a frame six inches high to prevent the slash from blowing away or being walked on inadvertently by people working in the area.

1/ Fahnestock, G. R. Inflammability of the current year's logging slash. Northern Rocky Mountain Forest and Range Experiment Station Research Note No. 124, August 1953.

Experimental Design

Ninety-six plots of chipped slash were laid out, interspersed with the 48 plots of natural slash in the Priest River logging slash laboratory. Forty-eight of the chipped plots duplicated the species on the 48 plots of natural slash.2/ The remaining 48 plots contained the same three weights of four additional species: ponderosa pine, lodgepole pine, grand fir, and western larch. The 24 possible species-weight combinations were randomized in four blocks of 24 plots each, corresponding in area to the four blocks of natural slash plots.

Experimental Burning

The 24 plots of block 1 were burned in September. After two unsatisfactory attempts to burn quite late in the afternoon when the wind velocity was lowest, the remainder of the burning program, involving 20 plots, was carried on between 1:00 p.m. and 4:15 p.m. The following weather and moisture conditions prevailed during the burning of the 20 plots:

Air temperature -- 74 to 87 degrees
Relative humidity -- 19 to 42 percent
Wind velocity -- 2.1 to 4.5 mph
½-inch stick moisture content -- 6.5 to 8.0 percent
Chipped slash moisture content -- 5.1 to 10.4 percent

In anticipation of slow and erratic fire spread a fine wire grid dividing the plot into 6-inch squares was used as the basis for measurement. Plots were ignited in the exact center by touching a match to a handful of dry material taken from the surface near one edge. At 2- to 5-minute intervals after ignition, the outline of the fire was sketched to scale on cross-section paper. The interval between sketches was varied to correspond with the rate of spread; that is, enough time was allowed to elapse that the new sketch would show an appreciable increase in area. After some of the early plots showed that spread was usually very slow, the policy was adopted of continuing measurement until the fire reached one edge of the plot, or until the end of 10 minutes, whichever was sooner. On the day after burning the final area burned was sketched for plots not completely covered by the fire within 10 minutes.

Rate of Spread Measurements and Computations

As anticipated, most of the experimental fires spread erratically. Therefore area was the only satisfactory basis for measuring rate of spread. Total area at each successive sketch was planimetered from the field sheets. The area of each succeeding sketch was assumed to represent the area of a circle, and the corresponding radius was calculated. Through subtraction the theoretical radial increase was obtained for each successive area burned. This computation process made possible the simplest form of comparison with data from the experimental burning of natural slash.

2/ Western white pine, western redcedar, Douglas-fir, and western hemlock.

RESULTS

General

Table 1 gives a general summary of the results. Data were too meager to permit satisfactory statistical analysis, but certain facts appear to stand out clearly enough to warrant comment and interpretation.

Table 1. Summary of the results of burning 0.001-acre plots of chipped slash in September 1952

Species	32.5 tons/acre		20 tons/acre		7.5 tons/acre		Average all weights	
	Radial spread	Percent burned	Radial spread	Percent burned	Radial spread	Percent burned	Radial spread	Percent burned
Western white pine	0.57	100	--	6.9	0.50	100	0.36	89.7
Lodgepole pine	0.31	100	0.38	100	0.09	56.3	0.26	85.4
Ponderosa pine	0.17	100	0.26	92.4	0.23	86.9	0.22	93.1
Grand fir	0.30	80.6	0.04	2.7	--	Spot	0.11	27.8
Douglas-fir	0.12	86.0	0.05	2.5	--	Spot	0.06	29.5
Western redcedar	0.08	81.1	--	Spot	--	Spot	0.03	27.0
Western hemlock	0.08	22.9	--	Spot	--	Spot	0.03	7.6
Western larch	0.07	56.2	--	Spot	--	Spot	0.02	18.7
AVERAGE, ALL SPECIES	0.21	78.4	0.09	25.6	0.10	30.4		

Note: Radial spread is calculated average increase in radius expressed as feet per minute. No rate was calculated for fires which did not spread during 10 minutes' observation.

The Effect of Species

Species appeared to be the strongest factor affecting rate of spread. The pines produced the hottest, fastest fires. Failure of the 20-ton-per-acre white pine plot to burn resulted from trying to burn it too late in the day when relative humidity was over 50 percent. Grand fir slash supported a rate of spread approximately half that in pine slash; Douglas-fir, about half that in grand fir; and cedar, hemlock, and larch grouped together with a rate about half that in Douglas-fir.

Length of needles was rather obviously the species characteristic which governed rate of spread. The long pine needles came through the chipper virtually intact and formed a jumbled surface relatively well exposed to the air throughout. At the other extreme the very fine desiduous needles of larch formed a uniformly compact mat.

Species also had a strong effect on the total area of the plot burned and on the character of the fires. The fires in pine tended to spread rapidly over the surface but often did not penetrate deeply into the mass of slash. In the case of species the slash of which formed a compact mass, relatively little of the area of the plot might be burned, but what was burned tended to be completely consumed down to mineral soil.

The Effect of Weight

In general weight appeared to have an appreciable effect on rate of spread, but an effect much weaker and less consistent than when natural slash was burned. From examination of table 1 it appears that had the 20-ton-per-acre white pine plot been burned under drier conditions, average rate of spread for all species would have declined rather regularly as weight was decreased. Weight did not appear to affect rate of spread among the pine plots, a conspicuous exception to the over-all situation. In more compact duff-like material, however, persistent and continuing spread of fire was encouraged by the thicker bed of fuel which resulted from greater weight per acre.

DISCUSSION AND CONCLUSIONS

Reduction of Inflammability

One major reason for burning experiments with chipped slash was to determine the effectiveness of chipping as a means of reducing inflammability. Table 2 compares the rates of spread in chipped and natural slash of the four species which were burned in both conditions. The indicated reduction in inflammability is very striking, particularly when one considers that the chipped slash was burned during the hottest, driest part of the day while natural slash was burned at evening, sometimes with very high relative humidity. The highest rate of spread in chipped slash was materially below the lowest rate observed in natural slash of species which retained their needles at the time of burning. The over-all average rate of spread in natural slash was 14 times that in chipped slash.

The rates of spread in chipped pine slash almost certainly would have been lower if the needles had been more thoroughly mangled by the chipper. Finer chips and more mangling of needles can be obtained by using one serrated knife in the chipper and by better adjustment of the cutting mechanism than could be made on the machine which chipped the experimental slash.

Reduction in volume is the key to reduction in inflammability. It has been shown that rate of spread of fire is inversely proportional to compactness of the fuels.3/ Unpublished research at the University of Idaho indicates that the volume of lopped slash in reduced -- and compactness thereby increased -- about 97 percent by chipping. The 93 percent reduction in inflammability measured in the present study therefore conforms closely with expectancy.

3/ Fons, Wallace L. Analysis of fire spread in light forest fuels. Jour. Agri. Research 72(3): 93-121. February 1946.

Table 2. Comparative rates of spread in chipped and natural slash

Species	Rate of spread[1]					
	32.5 tons/acre		20 tons/acre		7.5 tons/acre	
	Chipped	Natural	Chipped	Natural	Chipped	Natural
Western white pine	3.24	19.48	--[2]	9.65	2.88	4.17
Western redcedar	0.47	14.16	--[2]	6.28	--[2]	4.97
Douglas-fir	0.71	16.45	0.31	8.34	--[2]	4.57
Western hemlock	0.43	12.00	--[2]	7.94	--[2]	--[2]

1/ Rate of spread is expressed as rate of perimeter increase, chains per hour.

2/ Did not spread appreciably in 10 minutes.

Interpretation of Species Effect

The second main purpose of experimenting with the inflammability of chipped slash was to investigate the effect of species on rate of spread in more homogeneous fuel masses than could be assembled from natural slash. The 1952 tests showed that species could be a very important factor affecting rate of spread. It was apparent, however, that species affected rate of spread by controlling the fuel arrangement. Given equal weights of fuel spread over equal areas, arrangement was the factor which governed rate of spread. No variations in burning rate were observed which seemed to result from differences in chemical composition -- e.g., content of volatile fats and oils -- among species. Therefore the results of burning chipped slash support the findings of the natural slash burning program as regards species effect.

Practicability of Chipping

Testing the chipper as a practical tool for use in slash disposal was not a part of the inflammability experiments. Observations indicated, however, that on certain types of operations, for instance right-of-way clearing where slash is heavily concentrated in an accessible strip, use of the chipper would prove practicable. Such use would be particularly desirable for mid-summer operations when burning could not be permitted. It was apparent that use of the chipper in its present form would not be practicable or economical on the general run of slash disposal operations. Too much time would be consumed carrying material to the chipper and feeding it into the narrow throat. Furthermore, a wheeled trailer could not be pulled around through the woods successfully, even by a bulldozer, on some of the steep slopes common in the northern Rocky Mountains, especially over ground covered with logging debris. A chipper mounted on a crawler tractor and having more power, a wider throat, and possibly some form of self-feeding mechanism should have a good future in slash disposal.